International Space Station Status

Robyn Gatens
Acting Deputy Director, ISS
Tara Ruttley
Associate Program Scientist, ISS Program Office

HEO NAC
April 2015

Agenda

- ISS Goals
  - Highlight Exploration and Commercial Market Development
- ISS Overview Status
- Visiting Vehicle Status
- Utilization Highlights (Dr. Tara Ruttley)

NASA's and America's goals onboard the Station

Advance benefits to humanity through research

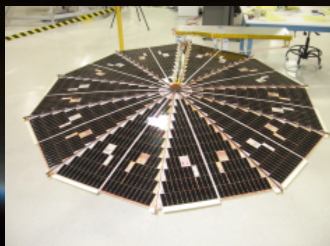
Enable long duration human spaceflight beyond LEO

Enable the commercial market in LEO

Basis for international HSF leadership & partnerships

ISS and Exploration

Exploration Systems Flight Testing on ISS



Solar arrays

Life Support Systems

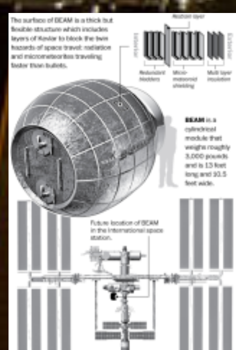
Crew Support Systems

NASA Docking System

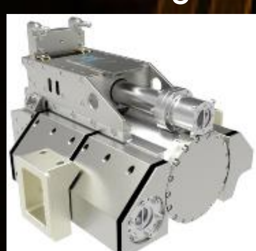
In-Space Manufacturing

Refueling

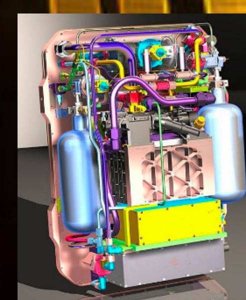
Crew Medical Systems



Habitation Structures



Leak detection



EVA Systems

Environmental Monitors

Technology Demonstration Progress & Planning

- NASA System Maturation Teams have identified gaps for future missions that can be enabled through ISS.

  - Reliable/low maintenance life support and environmental monitoring systems
  - EVA systems
  - Crew health research and countermeasures
  - Crew performance systems development
  - Rendezvous and docking system
  - Human robotic operations and capabilities
  - Mars mission-based simulations

- Working to prioritize and plan for demonstrations on ISS

- Near-term planned demonstrations include:
  - Life support system upgrades and on-board environmental monitors
  - Inflatable habitat structure
  - Large fire phenomenon
  - 3D printing
  - Low boil-off cryogenic fluid storage systems
  - Deployable solar array

Exploration Technology Fly Off Plan

Capability Gap	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
ECLSS															
Reliable CO2 Removal + lower ppCO2	CDRA-4			valve, bed upgrades				next gen system							
Smaller, simpler O2 Gen							next gen OGA								
High pressure O2 for EVA & medical use															
Reliable urine processing ~85% recovery			ISS UPA upgrades				next gen UPA								
Reliable water processing w/ reduced expendables				MF bed mod			cat reactor mod								
Common biocide with on orbit replenishment															
Waste management					UWMS			HMC							
Additional O2 recovery from CO2 >75%									>75% recovery						
Additional water from brine >85% recovery									brine processor						
Environmental Monitoring															
Trace Gas (on orbit, no grab sample return)	AQM				uTAM										
Targeted Gases (fire products, NH3, hydrazine)					saffire demo										
Water (individual compounds)															
Microbial (ID & qty species)				COTS		Expl PCR									
Major Constitutents (small, no maintenance)					uTAM	MPAM (ISS & Orion)									
Particulates				particulate survey			particulate monitor								
Acoustic (automated, alerting, no crew time)					tech demo		operational								
EVA															
PLSS & Pressure Garment															
EMU upgrades															
Suitport															
Fire Safety and Response															
Emergency Mask (single cartridge)	dual				single										
Contingency Air Monitor (overlap with targeted gas)					Saffire										
Smoke Eater															
Water Mist PFE			ISS size		Exp size										
Crew Health & Performance Technologies															
Exercise Equipment				Orion device				Exploration device							
Medical Equipment					ESMD										
Food System									Adv food system						
Thermal (including Cryo)															
ZBOT (Phases 1-3)				Phase I		Phase 2				Phase 3					
Phase Change Material				wax			water								
Variable Heat Rejection radiators															
Power & Energy Storage															
Solar arrays				ROSA		Common agency array									
Energy Storage				Li ion batt		Regen fuel cell									
Comm & Navigation															
High speed comm/internetworking	DTN & OPALS				LCRD						TDRS upgrades				
Position, navigation, and timing				NICER/SEXTANT											
Structures & Materials															
Materials/In-space manufacturing		3D print (plastic)			3D print (metal)										
Structures & Health Monitoring			BEAM												
Radiation Monitoring & Shielding		REM & others													
Entry, Descent, Landing								THOR							
Autonomous Operations		comm delay		increased crew autonomy											
Automated Rendezvous & Docking				RAVEN											
Robotics															
Robotic refueling		RRM2			RRM3										
Free flyer robots (IVA & EVA)			SPHERES2 (IVA)			EVA									
Human assist robots															
Telerobotics															

no committed funding
some $, but insufficient funding for ISS demo
sufficient funding to ISS demo

Funded ISS demo
Proposed ISS demo (not yet funded)

ISS and the Development of the Commercial Market

LEO Commercialization Strategic Planning

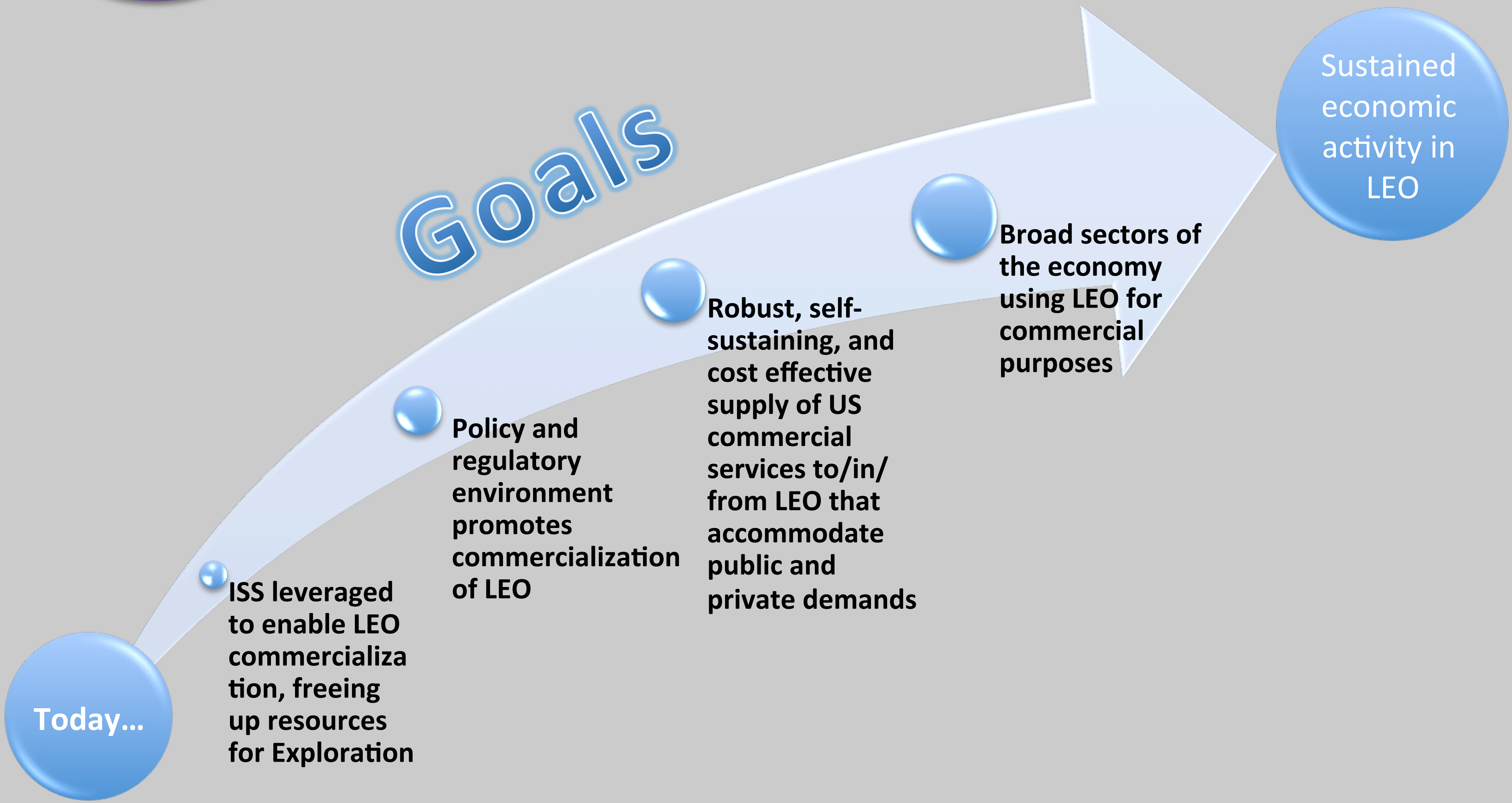
- Some summary finding highlights from Dec 10-11 Workshop
  - *Recommendation for NASA to develop a strategic plan for commercialization*
  - NASA should forecast needs for LEO beyond ISS and not be in competition with industry
  - Need for routine and regular access to ISS
  - More clarification on insurance, intellectual property rights, cross-waivers, and government and non-government use of materials developed on ISS
  - Potential government incentives could include free trade/tax free zones

- Complete workshop summary available at: http://www.nasa.gov/directorates/heo/LEO_commercialization

- Currently working on detailed strategic plan, including:
  - ISS transition objectives to further enable commercial development
  - Policy and economic initiatives
  - Supply and demand side stimulation

Vision

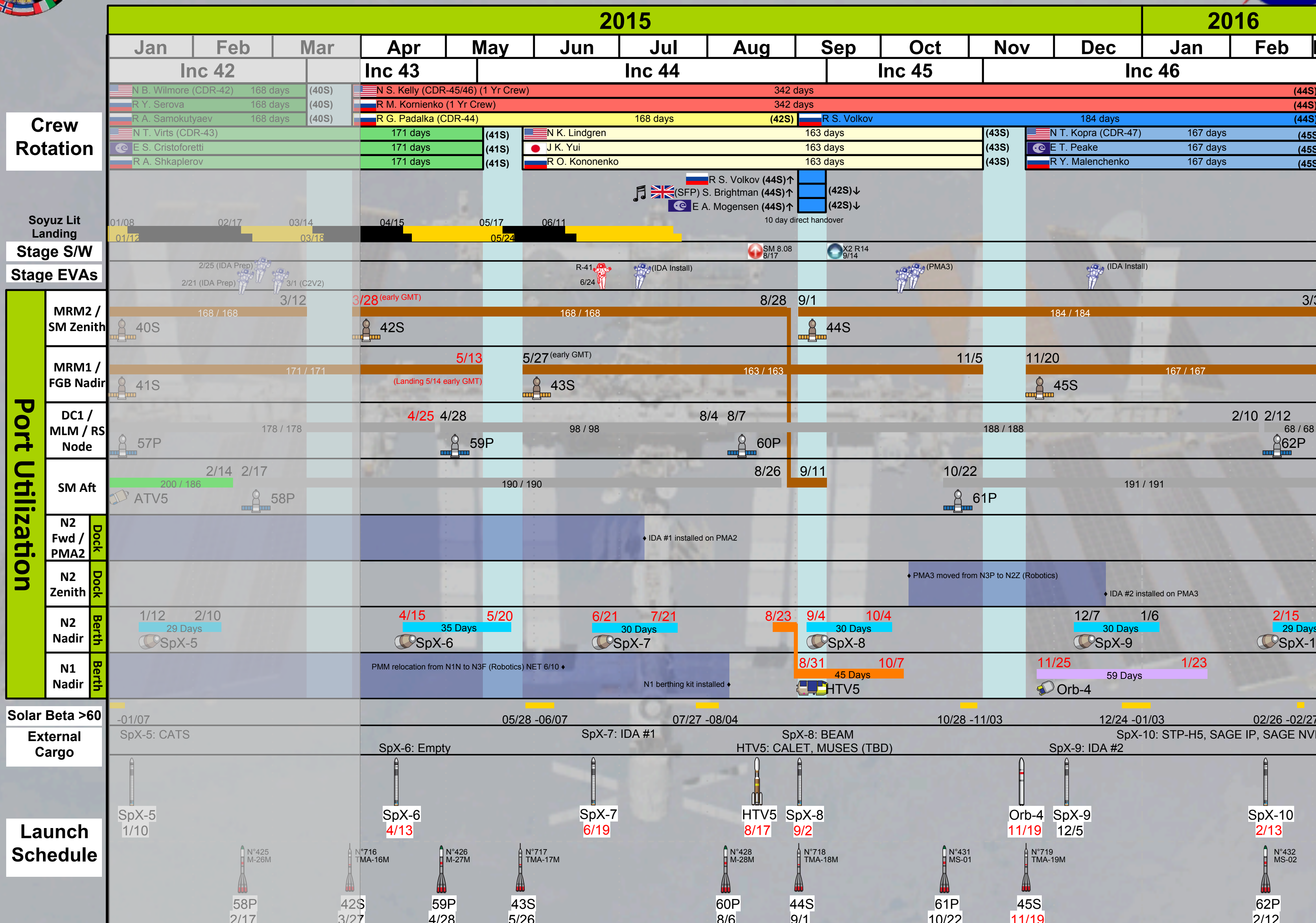
Sustained economic activity in LEO enabled by human spaceflight, driven by private and public investments creating value and benefitting Earth through commercial supply and public and private demand



ISS Overview Status

ISS Program
April 2015

NASA: OC4/John Coggeshall
MAPI: OP/Randy Morgan
Chart Updated: Mar 24th, 2015
SSCN/CR: 14322A,14434,14463,14493A
& 14498 (In-Work)



42 Soyuz Launch/Increment 43
March - September 2015

Vehicle: 42 Soyuz

Launch: March 27, 2015 (with 4 orbit rendezvous)

Docking: March 28, 2015

Undock/Landing: September 11, 2015

41 Soyuz crew

Anton Shkaplerov, Soyuz Commander
Terry Virts, Increment 43 Commander
Samantha Cristoforetti, (ESA) Flight Engineer

Undock / Landing : May 13, 2015

42 Soyuz Crew

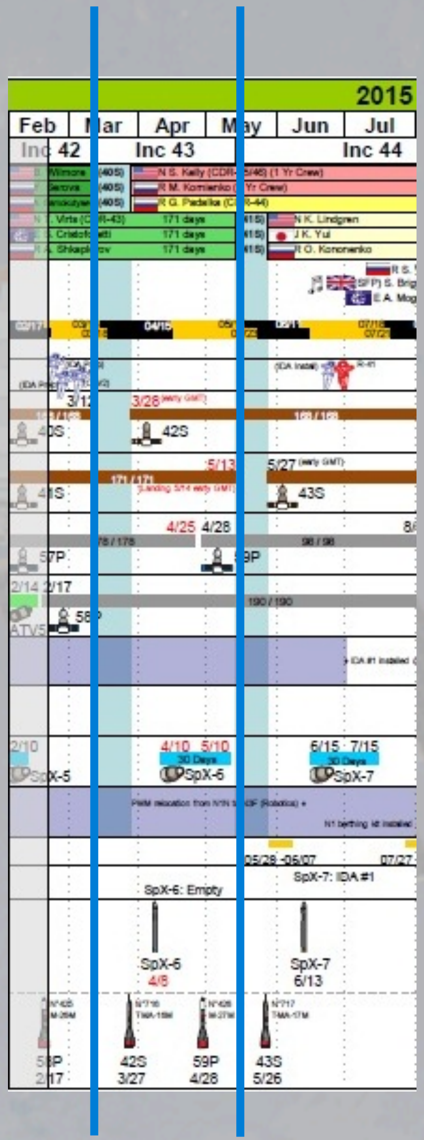
Gennady Pakalka, Soyuz and Increment 44 Commander
Mikhail Kornienko, Flight Engineer
Scott Kelly, Increment 45/46 Commander

Increment 43 and 44 Highlights

- Beginning of 1-year mission and associated experiments
- Rodent Research-2 is scheduled to start during SpX-6 and continue into Increment 44
- USOS Reconfiguration
  - Delivery and EVA installation of International Docking Adapter (IDA) – 1 (SpX-7)
  - PMM Relocation
  - Node1 Nadir Modifications
- Delivery of first NORS Tank
- HTV-5 use of Node1 Nadir for berthing
- CALorimetric Electron Telescope (CALET) External Payload (HTV-5)
- Arrival of Galley Rack and Multi purpose Small Payload Rack (MSPR-2) Rack (HTV-5)
- Direct Handover Stage 44-9 with 9 crew on ISS

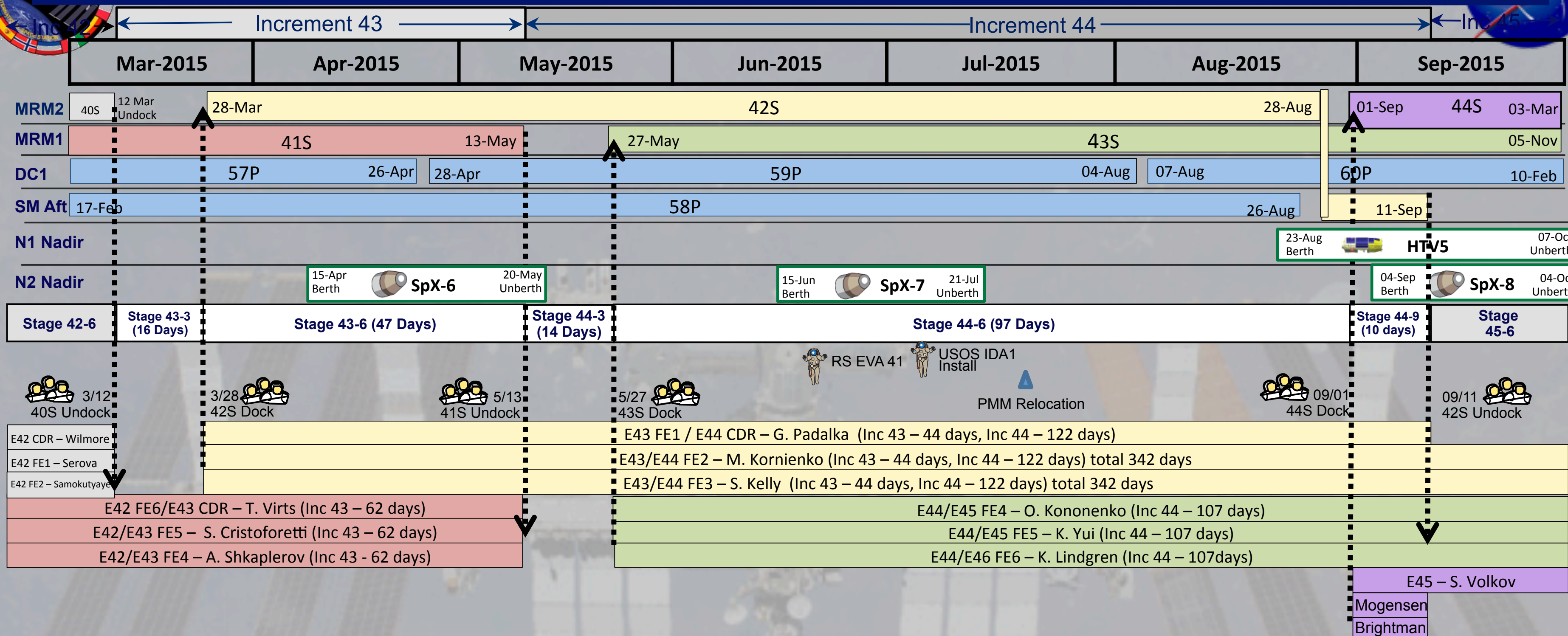
Increment 43 Overview - Major Stage Objectives

- Increment 43: 62 Days
  - Stage 43-3: 40S Undock to 42S Dock: 16 days
  - Stage 43-6: 42S Dock to 41S Undock: 46 days
  - EVAs
    - No planned EVAs
  - Cargo vehicles:
    - SpX-6 Launch/Berthing/Unberthing (4/13, 5/20)
    - 57P Undock from DC1 Nadir (4/25)
    - 59P Dock to DC1 Nadir (4/28)
  - Science/Utilization:
    - Inc 43/44 Utilization Target: 35 hrs per week avg (+ 170 hr "challenge")
    - Rodent Research 2
    - 1 Year Crew Human Research Program
    - Fluid Shifts

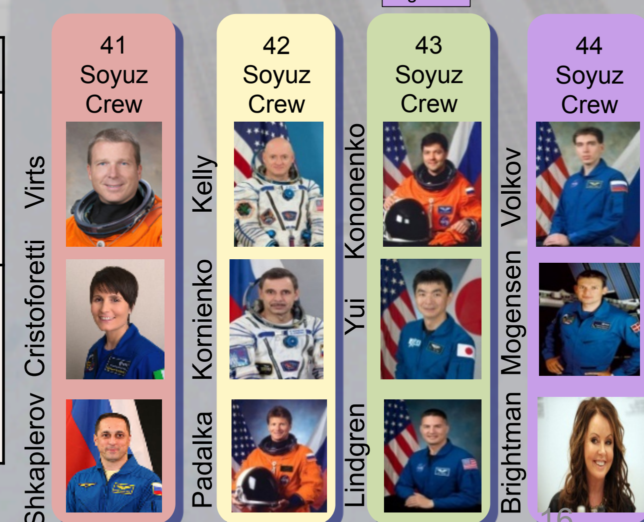


INCREMENTS 43 & 44

Updated 06-Feb-2015 All dates GMT
FPIP:SSCN/CR 14322A, 14348, 14434, 14463 (In-Work)
IDRD Rev A



	Stage 43-3	Stage 43-6	Stage 44-3	Stage 44-6	Stage 44-9
Utilization	• ~30 New Experiments • 1-Year Mission Experimentation • Twin Studies • Fluid Shifts • Rodent Research-2 • JEM A/L Candidate: RRM2		• ~45 New Experiments • JEM A/L Candidates: NRCSD, J-SSOD#3-2, ExHAM/Tanpopo		• ESA Visiting Crewmember Science complement
EVA, Robotics, Systems, Software	• Begin 1 Year Mission		• USOS EVA: IDA1 install • PMM relocate from N1N to N3F (SSRMS) • N1N berthing port prep • N1 Galley Rack and MSPR-2 xfer and install • USOS EVA: PMA3 disconnect and IDA2 cable routing (below the line) • RS EVA 41		



IM – Todd Hellner (x31394) IDM – Lisa Leech (x41101)
IE – Julie Dunning (x34360) IPE – David Bach (x46748)
IE – Cindy Cranford (x47677)

https://iss-www.jsc.nasa.gov/nwo/mio/riit/inc_43/web/

ISS Reconfiguration

- Goal : Establish 2 docking ports and 2 berthing ports on ISS USOS to support crew and cargo vehicles
- Present configuration : Berthing ports at Node 2 nadir, Node 2 zenith
  PMA 2 on Node 2 forward, PMA 3 on Node 3 port
- Final configuration : Berthing ports at Node 2 nadir, Node 1 nadir
  Docking ports at Node 2 forward (PMA 2 / IDA 1), Node 2 Zenith (PMA 3 / IDA 2)
- Move PMM from Node 1 nadir to Node 3 forward
- Move PMA-3 from Node 3 port to Node 2 zenith
- Install IDA 1 on PMA 2 (Node 2 forward) – SpaceX - 7
- Install IDA 2 on PMA 3 (Node 2 zenith) – SpaceX – 9
- Node 3 aft configured to support BEAM
- Install C2V2 antenna system on truss elements P3 and S3 (complete)
- Significant installation and rerouting of cables performed internally to the USOS
- Move ARED configuration in Node 3 (completed)

Total ISS Consumables Status

	T1: Current Capability		T2: Current Capability + SpX-6	
Consumable – based on current, ISS system status	**Date to Reserve Level**	**Date to zero supplies**	**Date to Reserve Level**	**Date to zero supplies**
Food – 100%	July 05, 2015	August 18, 2015	July 24, 2015	September 05, 2015
KTO	June 20, 2015	August 04, 2015	July 20, 2015	September 02, 2015
Filter Inserts	April 01, 2016	May 24, 2016	April 01, 2016	May 24, 2016
Toilet (ACY) Inserts	January 03, 2016	February 17, 2016	January 03, 2016	February 17, 2016
EDV + TUBSS (UPA Operable)	December 06, 2015	March 29, 2016	December 06, 2015	March 29, 2016
Pre-Treat Tank	August 20, 2015	September 29, 2015	August 20, 2015	September 29, 2015
Water (Nominal Usage)	September 10, 2015	December 24, 2015	September 10, 2015	December 24, 2015
Consumable - based on system failure				
EDV + TUBSS (UPA Failed)	August 26, 2015	October 14, 2015	August 26, 2015	October 14, 2015
Water, if no WPA (Ag & Iodinated)	July 19, 2015	September 17, 2015	July 19, 2015	September 17, 2015
O_2 if Elektron supporting 3 crew & no OGA	May 10, 2015	September 08, 2015	May 10, 2015	September 08, 2015
O_2 if neither Elektron or OGA	April 14, 2015	June 18, 2015	April 14, 2015	June 18, 2015
LiOH (CDRAs and Vozdukh off)	~0 Days	~14 Days	~0 Days	~14 Days

USOS Consumables Status

	U1: Current Capability		U2: Current Capability + SpX-6	
Consumable – based on current, ISS system status	Date to Reserve Level	Date to zero supplies	Date to Reserve Level	Date to zero supplies
Food – 100%	August 21, 2015	September 28, 2015	September 22, 2015	November 09, 2015
KTO	June 17, 2015	August 01, 2015	August 16, 2015	September 23, 2015
Filter Inserts	January 20, 2016	March 06, 2016	January 20, 2016	March 06, 2016
Toilet (ACY) Inserts	June 07, 2016	July 22, 2016	June 07, 2016	July 22, 2016
EDV + TUBSS (UPA Operable)	April 30, 2015	January 01, 2016	April 30, 2015	January 01, 2016
Pre-Treat Tanks	September 05, 2015	October 15, 2015	September 05, 2015	October 15, 2015
Water (Nominal Usage)	August 20, 2015	January 30, 2016	August 20, 2015	January 30, 2016
Utilization		> October 2015		> October 2015
Consumable - based on system failure				
EDV + TUBSS (UPA Failed)	April 03, 2015	June 22, 2015	April 03, 2015	June 22, 2015
Water, if no WPA (Ag & Iodinated)	April 19, 2015	June 21, 2015	April 19, 2015	June 21, 2015
O_2 if neither Elektron or OGA	April 17, 2015	July 05, 2015	April 17, 2015	July 05, 2015
LiOH (CDRAs and Vozdukh off)	~0 Days	~13.3 Days	~0 Days	~13.3 Days

Pertinent ISS Vehicle Issues

Issue	Impact to Stage Ops	Rationale
Node 3 CDRA ASV 104 Failure	Yes	Node 3 CDRA faulted after Air Selector Valve (ASV) #104 failed to transition position on 3/26/15. • Troubleshooting attempts successfully recovered the valve and Node 3 CDRA is currently in operation. • There are six ASV in CDRA. ASV #106 was replaced on 3/24/15. • Teams continue to monitor ASV #104 and will replace once hard failed. • There are 2 ASV spares on-orbit and one has been added to SpaceX-6.
WSTA Unexpected Quantity	Yes	After a completion of a nominal WSTA fill on 3/25/15, the quantity reading continued to increase to ~99%. This is a ~28% increase above the planned volume. • WSTA was drained and the remaining PTU was processed in the UPA. • To determine if the signature was repeatable the WSTA was filled again and the same quantity increase of ~28% was observed. • Probable cause is a combination of excessive free gas in the WSTA tank from a previous EDV transfer in conjunction with a flow restriction. • Proceeding forward with a partial WSTA fill during the next EDV PTU transfer. If quantity increase does not occur, nominal operations can resume.

Pertinent ISS Vehicle Issues (cont.)

Issue	Impact to Stage Ops	Rationale
WPA RHS High Conductivity	Yes	WPA Reactor Health Sensor (RHS) faulted during a process cycle on 3/25/15 due to a sharp increase in conductivity. • The exceedance of the tolerance limit between the two sensors caused the WPA to stop processing. • Ground teams inhibited the diverged sensor and proceeded forward with WPA process operations. • There is 1 spare RHS ORU on orbit and 1 spare Catalytic Reactor on SpX-6. • Teams are continuing to assess the cause of the sharp increase in conductivity.
PL-1 MDM Command Issue	Yes	On 3/26/15, Payloads were not providing the expected response to ground commanding required to support 42S docking inhibits. • Payload (PL)-1 MDM held a command in queue and would not process additional commands. Confirmed via data review and ground testing. • PL-2 MDM was moded to primary which allowed POIC to put inhibits in place for 42S. • A command error uncovered a latent code issue that changed the command queue structures. An SCR will be written to address this issue. • The condition was cleared by a PL-1 MDM power cycle. • An alternate workaround has been identified

Pertinent ISS Vehicle Issues (cont.)

Issue	Impact to Stage Ops	Rationale
AQM 2 Sieve Cartridge Replacement	No	JSC Toxicology's review of AQM 2 data indicated the sieve cartridges were spent and required replacement. • AQM sieve cartridges on-orbit life is estimated at 6 months and are trashed when replaced. • The last sieve cartridge change-out occurred on 1/20/15, change-out of the cartridges was completed on 3/20/15. • Improper installation is considered the most probable cause. • There are 3 sets of spare cartridges on-orbit.
MERLIN 2 System Lock Up	No	On 3/19/15 MERLIN 2 was deactivated by the ground after it hung up following a planned reboot and was no longer was reporting health and status. • After an unsuccessful power cycle, Crew confirmed the unit is hung-up in the reboot cycle. • A troubleshooting plan is in development. • MERLIN 2 holds Crew Preference Items, which have been consolidated in the MERLIN galley unit.
N3 CDRA Failed Heater Annunciation by N3-1 MDM	No	After N3 CDRA was powered (part of a reconfiguration activity), both heater controllers were reported to be failed by the N3-1 MDM. • A discrepancy was found between the enable/disable states of the heater controllers by the N3-1 MDM during a scheduled N3-1 EEPROM Refresh. • Heater controller communication was reestablished by ground teams.

Pertinent ISS Vehicle Issues (cont.)

Issue	Impact to Stage Ops	Rationale
ARED Cylinder Replacement	No	Recently, a sharp increase in ARED cylinder evacuations were required. • Indications of a leak due to multiple bar rises with loads dialed to less than 590lbs. • Troubleshooting confirmed that the left cylinder was unable to maintain a vacuum. • Both cylinders were replaced with two pristine spares. • The removed right cylinder will be stowed as a usable spare. The removed left cylinder will be returned on SpX-6.
Lab CDRA RPC Trips	Yes	RPCM LAD62B-A, RPC 12, which provides power to the Lab CDRA Air Selector Valves, continues to have true overcurrent trips. • Trip signatures have all been in family. • Troubleshooting will be conducted once the trip frequency is inconsistent. • Multiple RPC trips do not degrade RPCs and upstream hardware is protected by stepped increases in wire and RPCM amp ratings.
RPCM AL2A3B_B RPC 5 Trip	No	On 3/8/15, RPCM AL2A3B_B RPC 5 tripped (no overcurrent) and had a power on reset. • This RPC powers the Airlock CCAA TCCV (auto control capability). • FET hybrid troubleshooting confirmed RPC 5 failed and will require an RPCM R&R. All other loads on this RPCM were recovered. • No constraint to operate CCAA fan w/o TCCV commanding. Manual air temperature control can be conducted. • The RPCM was successfully replaced on 3/30/15.

Pertinent ISS Vehicle Issues (cont.)

Issue	Impact to Stage Ops	Rationale
Sabatier Status	Yes	Sabatier has operated in a degraded mode (with wet indications near the Reactor Inlet) since June of 2013. • On 2/6 crew removed Laminar Flow Element (LFE) rod and returned on SpX-5. • Production in February was 3.6 L of water, and current production in March is 8.4 L of water. • Sabatier Team continues to monitor system and adjust tolerances as required for operation.
SPDM RMCT Collets	Yes	On 2/2/15 a checkout of Robotic Micro Conical Tool 1 (RMCT 1) resulting in an inability to remove the RMCT from the Tool Holster Assembly (THA). • RMCT 1 troubleshooting occurred on 3/4/15. • Launch locks were closed, collets were opened to release RMCT1. Collets were cycled once for data collection. • Review of data indicates higher than expected torque values at various points during operation. • Teams are continuing to conduct a systematic engineering analysis and requesting additional on-orbit troubleshooting. • Upcoming RRM activities will be conducted with one SPDM arm ops.

Pertinent ISS Vehicle Issues (cont.)

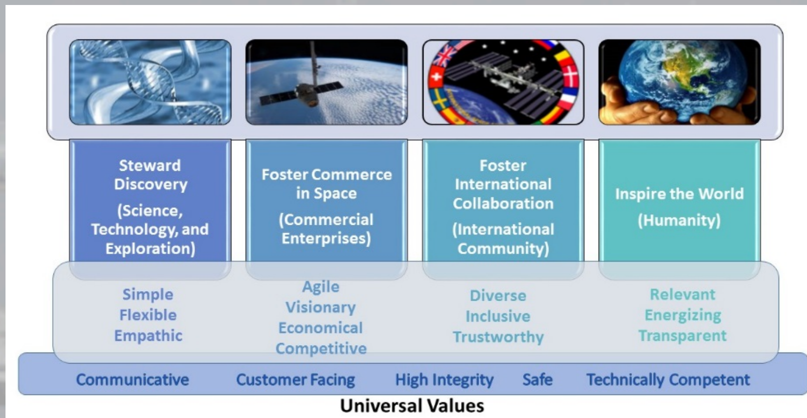
Issue	Impact to Stage Ops	Rationale
Two UPA FCPA Failures	No	On 2/18/15 the UPA faulted out due to a high pressure indication from the FCPA (S/N 6) P11 pressure switch. • FIT believed a faulty P11 switch was likely cause. FIT recommended to bypass redundant switch with pin-kit jumper. • During bypass operations, found pretreated urine leak within the FCPA that may have been causing issues with electrical connections. • FCPA was replaced on 2/23/15 The new FCPA (S/N 1) operated 45 minutes and then faulted due to high motor current. • FIT on 26 Feb 15 determined S/N 1 failed. New FCPA was installed on 3/3/15 and is currently in operation. • No spares on-orbit. Spares planned for SpX-6 and SpX-7.
EMU 3003 Suit P Erratic Sensor Readings	No	During EVA #31 (3/1/15) ISLE prebreathe activities, the suit pressure on EMU 3003 was erratic while in the IV O2 actuator position. • Erratic readings cause numerous annunciations. • Manual suit gauge pressure indicated a stable pressure. • Suit pressure was stable once O2 actuator was moved to the higher EVA pressure (4.2 psid) for the duration of the EVA. • Per FR B15-52, the EMU is go for EVA with the loss of the suit pressure sensor alone (manual gauge is available).

Revolutionize ISS for Science and Exploration

RISE
REVOLUTIONIZE ISS FOR SCIENCE AND EXPLORATION

The Approach

- Dedicated team of ISS and JSC personnel spent 4 months re-engineering ISS Core and Enabling processes.
- Transitioning ISS culture and processes from "assembly" mode to "science discovery/ commercialization" mode.
- Design solution marries resolution of current known issues from stakeholder and customer feedback with new process designs.



ISS Core Processes Highlights

- Utilize specific criteria and rating levels to define support providers need/want to achieve success in the realms of Safety, Requirements, and Operations
- Utilize dashboard concept for data sharing across the program
- Utilize rating and complexity categorization to define safety approval process
- Rewrite of payload interface requirements to reduce duplication and transfer mission success responsibility to the hardware provider).
- Eliminate duplicate data submittal.

The Focus	The Customer	The Purpose
	Core Processes	ENSURING SAFETY with DILIGENCE, FLEXIBILITY, TECHNICAL EXCELLENCE and DISCERNMENT
	Core Processes	MANAGE ST&E INTERFACES with EFFICIENCY, FLEXIBILITY, and CONSISTENCY
	Core Processes	PLAN AND PROCESS CARGO with EFFICIENCY, FLEXIBILITY, and RELIABILITY
	Core Processes	PLAN OPERATIONS with EFFICIENCY, FLEXIBILITY, and RESPONSIVENESS
	Core Processes	OPERATE THE VEHICLE with TEAM WORK, EFFICIENCY, and SERVICE

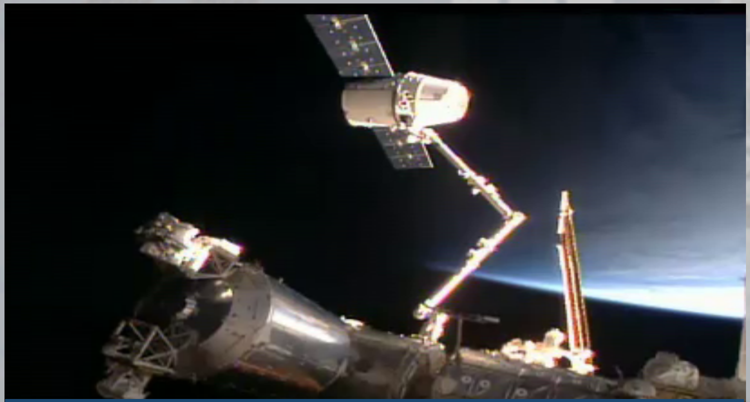
RISE Enabling Process Focus
"Making the right thing to do, the easiest thing to do."

Visiting Vehicles Status

SpX-5 Mission Success!

Falcon 9 successful launch on 1/10/15

Dragon successfully captured and berthed on 1/12/15



Dragon successfully unberthed on 2/10/15

SpaceX-5 Mission Status

- **Mission Planning**
  - Stage Operations Readiness Review (SORR) conducted on 11/18/14
  - SpaceX Launch Readiness Review (LRR) conducted on 1/4/15
  - Delta LRR was conducted on 1/8/15
  - Successful launch on 1/10/15
  - Berthing to ISS successful on 1/12/15
  - Preliminary Post Flight Briefing Part 1 was completed on 1/23/15
  - Successfully unberthed and splashed down on 2/10/15
  - Preliminary Post Flight Briefing Part 2 was completed on 3/2/15
  - Final report is scheduled for Apr
- **Pressurized Cargo**
  - GLACIER, Commercial Generic Bioprocessing Apparatus (CGBA), 2 Polar, and 6 Cold Bags
- **External Cargo**
  - Cloud Aerosol Transport System (CATS); CATS transferred to ISS successfully on 1/22/15
- **Dragon Status**
  - Successfully berthed to ISS on 1/12/15 and hatch opening was conducted on 1/13/15
  - Successfully unberthed and splashed down on 2/10/15 and expedited critical return to NASA
  - Water intrusion in the hatch on landing was successfully mitigated
  - Dragon arrived at McGregor on 2/14/15
  - Nominal cargo turned over to NASA on 2/17/15


Successful splashdown on 2/10/15


CRS-5 being brought in to port on 2/10/15

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SpaceX-6 Mission Status

- **Mission Planning**
  - Cargo Integration Review (CIR) was conducted on 12/4/14
  - Safety Review Panel (SRP) Phase 3 Part 1 was conducted on 3/3/15 and SRP Phase 3 Part 2 was conducted on 3/11/15
  - Post Qualification Review (PQR) was conducted on 3/4/15
  - Stage Operations Readiness Review (SORR) held 4/2/15
  - Launch 4/13, return 5/20
- **Pressurized Cargo**
  - 2 Polar, 1 Rodent Transporters, Cold Bags, 1 JAXA ice box and Osteo-4 (automated bone cell culture system)
  - High priority ECLSS spares
- **External Cargo**
  - No external payload
- **Dragon 8 Status**
  - Capsule and trunk stacking was performed in Jan for integrated checkouts
  - Electromagnetic Interference (EMI) testing was completed in Jan
  - Solar array installation and checkout was completed on 2/22/15
  - Dragon capsule and trunk arrived at the Cape on 3/4/15
  - Nominal cargo load was 3/23/15
- **Falcon 9 Status**
  - Stage checkouts were completed at McGregor, TX in Mar
  - Interstage arrived at Cape on 3/19/15
  - Shipped Stage 1 to the Cape on 3/22/15 and Stage 2 on 3/24/15

SpaceX-7 Mission Status

- **Mission Planning**
  - Cargo Integration Review (CIR) Part 1 was conducted on 12/5/14
  - CIR Part 2 was completed on 2/24/15
  - Launch 6/19, return 7/21
- **Pressurized Cargo**
  - 3 Polar
- **External Cargo**
  - International Docking Adapter (IDA) #1
- **Dragon Status**
  - Cargo rack production is underway
  - Trunk integration work is underway
  - Pressure section avionics power was completed in Feb
  - Trunk completion planned for Mar and Capsule completion planned for Apr
  - Stacked ops and EMI/EMC testing planned for Apr
- **Falcon 9 Status**
  - Engines began Acceptance Test Procedure (ATP) in Mar
  - First and Second Stages continuing production work with plan to ship to TX for ATP in Apr
  - Interstage production began in Feb with proof test planned for Apr

Orbital-3 Anomaly

- Orbital Sciences Corporation's Antares rocket experienced a catastrophic failure shortly after liftoff at 6:22 p.m. EDT Tuesday, Oct. 28, from Pad 0A of the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility in Virginia.
- The Accident Investigation Board (AIB) was formed by Orbital under the oversight of the Federal Aviation Administration (FAA).
- Orbital is leading the anomaly investigation. This conforms with the Commercial Resupply Services (CRS) contract.
  - *"In the event of an anomaly or failed mission, a Contractor-chaired Failure Review Board (FRB) will determine the cause of anomaly or failure, if activated. The FRB will evaluate all available data from the launch vehicle, orbital vehicle, Range, and other sources in order to determine if the mission failure was attributable to the vehicle or conditions which the Contractor is expected to control or avoid. Based on the findings and recommendations of the FRB, NASA shall make the final determination as to Partial Mission Success or Failed Mission."*
- NASA is a member of Orbital's Accident Investigation Board (AIB) per CRS contract SOW, Section 2.0, "*In the event of an in-flight anomaly or launch, on-orbit or entry failure, the Contractor shall allow NASA to participate fully in the Contractor's Failure Investigation Board including those for non-NASA missions.*"
- Since the Antares vehicle does not enter the command and control zone of the ISS, the ISS Program only certifies the Cygnus vehicle for its readiness to approach and berth to the ISS. However, NASA is conducting an independent review of the Antares failure in support of the CRS contract with a final briefing to Orbital on 3/25/15.

Orbital's Return To Flight (RTF) Plan

- The Orbital Sciences Corporation submitted an RTF proposal to NASA on 12/17/2014
- Orbital and NASA finalized the CRS contract modifications based on Orbital's RTF plan on 1/23/2015
- <u>Significant changes include:</u>
- Performing the basic contract cargo capability in 4 missions versus 5 missions
- Delaying the launch schedule but still flying all missions by the end of CY2016
- Modifying the packing layouts and the secondary structure to provide additional cargo on each mission
  - Lengthened on-orbit stay for cargo operations
- Improved performance on launch vehicles to carry heavier loads
  - Contracting with ULA to use an Atlas V 401 to launch the Orb-4 mission and a second Atlas V 401 as a backup plan for the Orb-5 mission to reduce launch slip risk
  - Antares design modifications including replacing the AJ-26 engine with a new RD-181 engine
- Incorporating the SSP 50808 Revision E "ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD)" design requirement updates
- <u>Summary:</u>
- There is no change in the contract value to support these contract changes

Orbital-4 Mission Status

- **Mission Planning**
  - Orbital has contracted with United Launch Alliance (ULA) for an Atlas V launch of Cygnus with an option for a second Atlas V launch if needed
  - Atlas/Cygnus Integrated Mission Review (IMR) #1 is planned for 4/9/15
  - Atlas/Cygnus IMR #2 is planned for 5/15/15
  - Cargo Integration Review (CIR) planned for early Jul
- **Pressurized Cargo complement**
  - Final ISS cargo manifest will be due at Launch minus 5 (L-5) months tentatively planned for Jun
- **Cygnus Status**
  - First enhanced Cygnus with a longer Pressurized Cargo Module (PCM)
  - Service Module (SM) will accommodate changes to the TriDAR/LIDAR configuration
  - SM Open Panel assembly was completed in Jan
  - SM Initial Integrated Systems Test (IIST) scheduled to begin in Apr
  - PCM is planned for delivery to the Cape in Jun
  - SM planned to be completed in Jul with shipment to the Cape in Aug
- **Atlas V 401**
  - A Technical Interchange Meeting (TIM) with Orbital and ULA was conducted in Feb to discuss range schedule, launch vehicle integration, and cargo processing
  - Design and development of a new Payload Adapter is progressing to support the launch of Cygnus on the Atlas V 401

Atlas V 401 launch vehicle planned to carry Cygnus in Orb-4 mission

Orb-4 Service Module (SM)

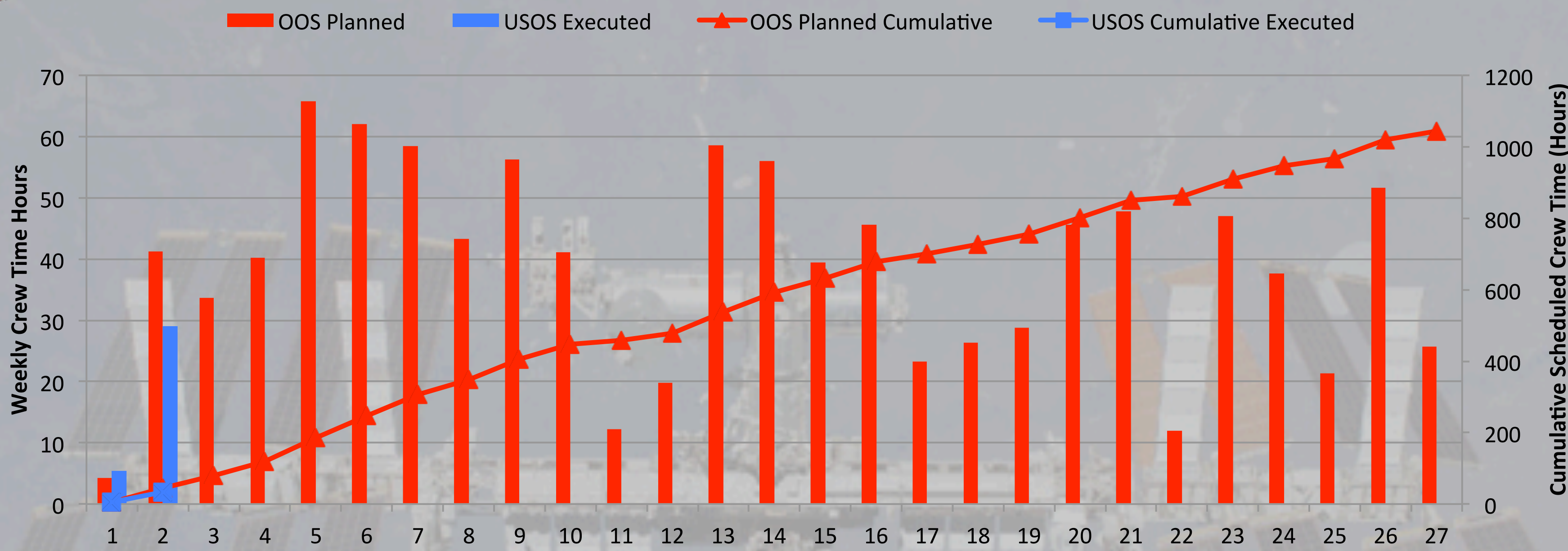
Photo Credit: Orbital

CRS-2 Status

- Draft CRS-2 RFP released Jun 16, 2014 to allow 2-3 months for industry feedback
- Pre-solicitation conference with industry held Aug 7, 2014 with 23 different organizations participating
- RFP released Sept 25, 2014 with proposals due Dec 2, 2014
- Competitive Range determination is planned for Apr 2015
- Selection expected Jun 2015
- CRS-1 contracts extended for 4 flights in 2017

Utilization Update

Inc 43 - 44 Utilization Crew Time



3-Crew	6-Crew	3-Crew	6-Crew	9-Crew

Increment 43	Increment 44

Mar	April	May	June	July	Aug	Sep

Color Key:
Final OOS
FPIP Plan
Completed

40S Undock 03/11/15

SpX-6
Berth 4/10/15
Berth 4/12/15
Unberth 5/17/15
Unberth 5/21/15

RS EVA 41

SpX-7
Berth 6/15/15
Unberth 7/15/15

US EVA 7/7/15

HTV5
Berth 8/23/15 N2N
Relocate 8/24/15 N1N

Undock 09/11/15
Undock 09/11/15

Soyuz relo 8/28/15

SpX-8
Berth 9/4/15

OP/OZ reconciliation is complete through Week 2.

Executed through Increment Wk (WLP Week) 2 =	1	of 25.0 work weeks (4 % through the Increment)
USOS IDRD Allocation:	1045.1	hours (41.8 hrs/week)
OOS USOS Planned Total:	1045.1	hours
USOS Actuals:	34.42	hours
	3.29%	through IDRD Allocation
	3.29%	through OOS Planned Total
Total USOS Average Per Work Week:	34.42	hours/work week
Voluntary Science Totals to Date:	0	hours (Not included in the above totals or graph)
RSA/NASA Joint Utilization to Date:	0	Hours (not included in the above totals or graph)

ISS Occupancy Highlights *(data as of February 2014)*

- Internal Occupancy 81%
  - Express racks: will launch additional Express to support small payloads in 2017
  - Microgravity Sciences Glovebox: oversubscribed, will launch a 2nd glovebox to deconflict life and physical sciences
- Crew time heavily oversubscribed
  - Human research and rodent research demand is high, and is crewtime intensive
  - National Laboratory/CASIS demand has grown to fully use the 50% allocation granted in the NASA Authorization of 2010 for crewtime beginning in late 2015, requiring a replanning of NASA-funded research
  - 4th crew member (with commercial crew ~2017) will almost double crew time for research
- External Occupancy (instruments for astrophysics and Earth Science)
  - CATS (Cloud Lidar) and Rapidscat (Scatterometer) launches in 2014
  - 3 sites left after the end of the year (SAGE, NVP, STP-H5), 70%
  - Only 2 sites available in 2017

ISS Research Statistics

Working data through Feb 28, 2014

Number of Investigations for 43/44 : 356

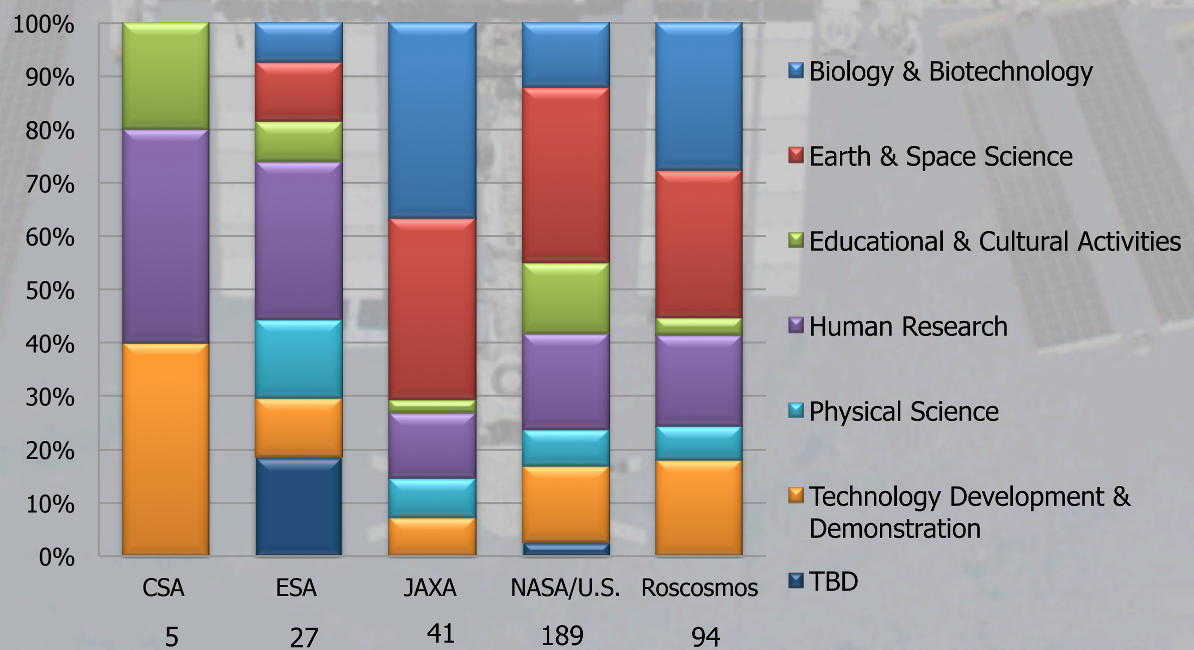
- 189 NASA/U.S.-led investigations
- 167 International-led investigations
- 95 new investigations
    - 1 CSA
    - 13 ESA
    - 9 JAXA
    - 64 NASA/U.S.
    - 8 Roscosmos *(preliminary data)*

Statistics Exp 0-40*

- Over 800 investigators represented
- Over 1100 scientific results published
- 1765 individual investigations

**Expeditions 0-40 statistics approved by the Program Science Forum in February 2015; pending approval by Space Station Control Board, and Multilateral Coordination Board*

Expeditions 43/44
Research and Technology Investigations



Model Organisms on ISS
Examples from 2014-2015

Worms (C elegans):

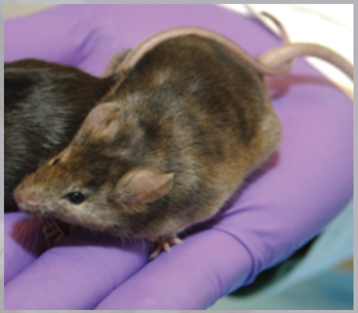
- JAXA: "Epigenetics" (Spx-5) studies impacts of microgravity on basic DNA across multiple cell generations. "Nematode Muscle" (Spx-6) studies muscle atrophy molecular mechanisms *(muscle)*.

- NASA: "Micro 5" (Spx-5) infects C elegans with Salmonella typhimurium and follows the survival of the C. elegans on orbit *(immune)*.

Rodents:

Rodent Research-2 (Spx-6, NASA, National Lab)

- studies the immune system response under simulated infection *(immune)*.
- studies the effects on intracranial pressure *(vision)*.
- Bone remodeling with periodic measures throughout the flight



Fruit Flies (Drosophila):

Fruit Fly Lab-01 (Spx-5, NASA) will enable the study of microbial interaction, microgravity, and radiation on fruit flies on ISS *(immune)*. *hardware failure, reflight planned in replacement hardware*.

Plants (Arabadopsis):

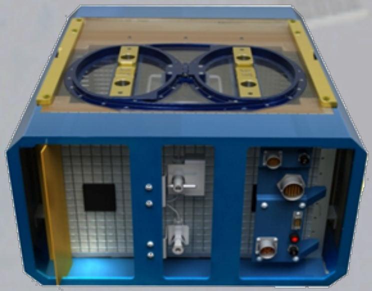
Plant Gravity Sensing 1&2 (Spx-4, -6 NASA) studies the structures involved in calcium signaling required for plant growth under various microgravity conditions (*optimal plant growth)*.

Studying model organisms in space contributes to understanding basic processes that can also be applied on Earth, such as treatments for disease, improvements for injured or aging populations, and innovative agricultural processes.

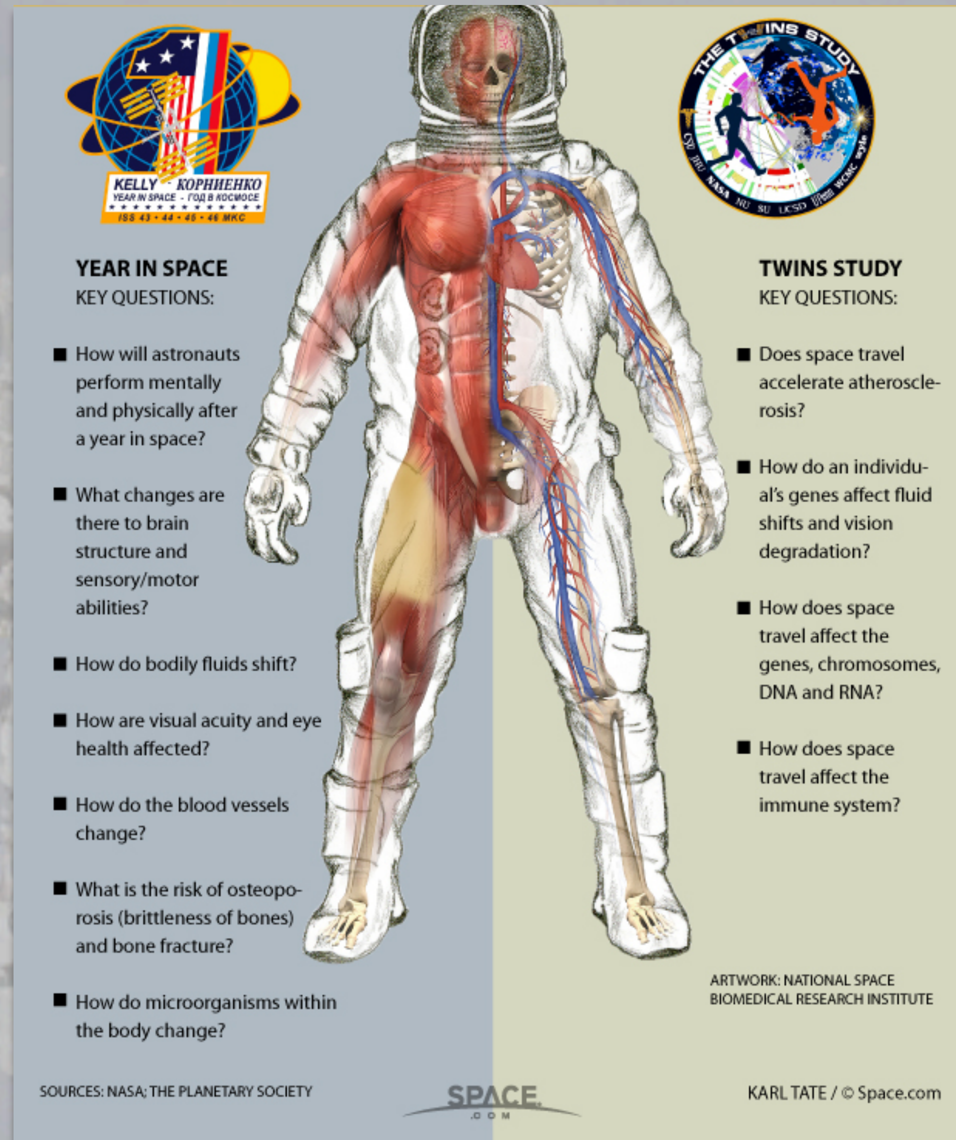
First Flight of Rodent Research System

"The lack of an animal facility for rodents on the ISS suitable for long-duration studies on adult animals is a major research impediment that will hamper the ability to obtain information important for maintaining astronaut health and fitness for duty." *-NRC Decadal Survey, 2011.*

- **<u>"Rodent Research-1"</u>** September-November 2014
  - 10 "NASA" mice dedicated to evaluation of hardware and on-orbit operations (Launched and samples returned on SpaceX-4).
  - 10 "National Laboratory" mice: Pharmaceutical company evaluating muscle atrophy (Launched on SpaceX-4, samples returned on SpaceX-5)
  - On orbit dissections, tissue sharing, evaluation of data retrieval from returned frozen carcasses



ISS One-Year Mission



http://www.nasa.gov/exploration/humanresearch/index.html

Increment 43 & 44
Research Complement Snapshot

Human Research

Bone & Muscle Physiology
Bisphosphonates (Control), Check-Saliva (Bone/Muscle Check) (ASI), IVD (P), Force Shoes, Hip QCT (P), Sprint, Marrow C/O, Tbone, Brain-DTI (P), CARTILAGE (P), EDOS-2, IMMUNO-2

Cardiovascular & Respiratory Systems
Cardio Ox, Drain Brain (ASI), Orthostatic Tolerance (ASI), Wearable Monitoring↓ (ASI), BP Reg, Vascular Echo C/O, IPVI

Human Microbiome
Microbiome, Myco

Crew Healthcare Systems
Medical Consumables Tracking, Skin-B

Vision
Fluid Shifts, Ocular Health

Habitability & Human Factors
Astro Palate, Body Measures, Fine Motor Skills, Habitability, Training Retention

Human Behavior & Performance
Cognition, Journals, Reaction Self Test, Sleep ISS-12, Space Headaches, Synergy (P)

Immune System
Salivary Markers, Multi-Omics (MAHM)↑

Other
Content, Interactions-2, Pilot-T

Integrated Physiology & Nutrition
Biochem Profile, Field Test (P), FTT (P), Repository, Telomeres, Twins Study, Circadian Rhythms, Energy, MARES Commissioning Part 1*, Biological Rhythms 48hrs

Nervous & Vestibular Systems
Manual Control (P), NeuroMapping, Straight Ahead in Microgravity (P), V-C Reflex (P)

Biology and Biotechnology

Animal Biology
Micro-10, Rodent Research-2, Rodent Research-2, Rodent Research-3, Rodent Research-3, Embryo Rad, JAXA Mouse Habitat Unit C/O, Nematode Muscles, Space Aging, Space Pup

Macromolecular Crystal Growth
CASIS PCG 3, CASIS PCG-4, NanoRacks PCG, JAXA PCG-9, JAXA PCG Demo

Plant Biology
BRIC-21, Plant RNA Regulation*, Veg-03, Aniso Tubule, Plant Gravity Sensing-2, -3, Plant Rotation

Microbiology / Cellular
CASIS Dev 6, CASIS Stem Cell-2, Cell Shape and Expression (ASI), Micro-9, Microbial Observatory-1, Nanoparticles and Osteoporosis (ASI), Osteo-4, RJR Microbial Sampling*, VIABLE (ASI), CYTOSKELETON, ENDOTHELIAL CELLS, SPHEROIDS, Stem Cell Differentiation, TripleLux-A, Cell Mechanosensing-3, Microbe-IV, Stem Cells

Physical Sciences

Combustion Science
FLEX-2, FLEX-2J, ATOMIZATION, Group Combustion

Complex Fluids
ACE-H1, ACE-H2, ACE-T1, OASIS, PK-4

Fluid Physics
BCAT-KP-1↓, Microchannel Diffusion*, PBRE, ZBOT↑, Dynamic Surf-2↓, Dynamic Surf-3, Marangoni UVP

Materials Science
Synthetic Muscle, EML Batch 1, ELF, ELF1, ELF2, Interfacial Energy

Earth & Space Science

Astrobiology/Astrophysics/Heliophysics
AMS-02 (E), Meteor, EXPOSE-R2 (E), Solar-SOLACES/SOLSPEC (E), CALET (E), ExHAM#1(E), #2(E), MAXI (E), MCE (E)

Earth Remote Sensing
CATS (E), CEO, HICO-RAIDS (HREP) (E), IMAX, ISERV, ISS-RapidScat (E), NREP Inserts (E), MUSES (E)

Near-Earth Space Environment
SEDA-AP (E)

Technology Development and Demonstration

Air, Water, & Surface Monitoring
Multi-Gas Monitor

Avionics & Software
SNFM

Characterizing Experiment Hardware
Capillary Beverage, POP 3D (ASI), MVIS Controller-1

Communications & Navigation
LONESTAR, OPALS (E), SCAN Testbed (E), Vessel ID System

Food & Clothing Systems
ISSpresso (ASI)

Life Support Systems & Habitation
AMO-TOCA, UPA (PCPA/FCPA), UBNT

Microgravity Environment in ISS
WetLab-2

Power Generation/Distribution Services
Universal Battery Charger

Radiation Measurements & Shielding
REM, Radi-N2, DOSIS-3D, Area PADLES-14, -15, PS-TEPC, Free-Space PADLES

Other
JAXA Commercial
SDM: 3D-VIT, Skin Suit, MOBIPV

Robotics & Imaging
3DA1 Camcorder, HDEV (E), Moon Imagery, Robonaut, RRM-Phase 2 (E), Haptics-1

Small Satellites & Control Technologies
NanoRacks MicroSats-Hi-Sat, NRCSD CubeSats, SPHERES-Slosh, SPHERES UDP, JSSOD CubeSat

Spacecraft and Orbital Environments
ISS External Leak Locator (ALL)

Space Structures
BEAM

Educational Activities

Classrooms Versions of ISS Investigations
Windows on Earth

Educational Demos
Sally Ride EarthKAM, Story Time from Space-3, Tomatosphere-IV, JAXA Try Zero-G for Asia

Educational Competitions
NanoRacks Ardulabs, NanoRacks Module-9, SPHERES-Zero Robotics

Student-Developed Investigations
CASIS Edu-2, NanoRacks Module-33 (NR-AGAR), NanoRacks Module-53 (Lakewood Plant Chamber), NanoRacks Modules-16, -18, -20, -21, -22

Other
CASIS Dev 7, Exomed-3, EPO-CRISTOFORETTI, ESA-EPO-PEAKE↑, EPO IRISS (SDM), JAXA EPO

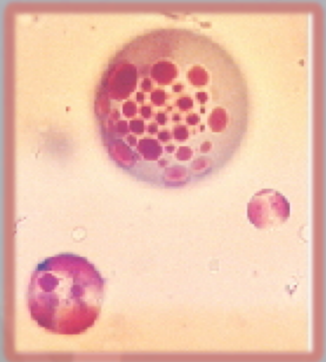
Cultural Activities
NanoRacks Module-48

3-March-2015

(P) Pre/Post only, **(E)** External Payload
Includes CEF changes as of 2/12/15, *CEF approval pending
↑/↓ Launch/Return only

Key: NASA, CASIS, CSA, ESA, JAXA, ROSCOSMOS

Advancements Enabled by ISS Research



What was done in space:

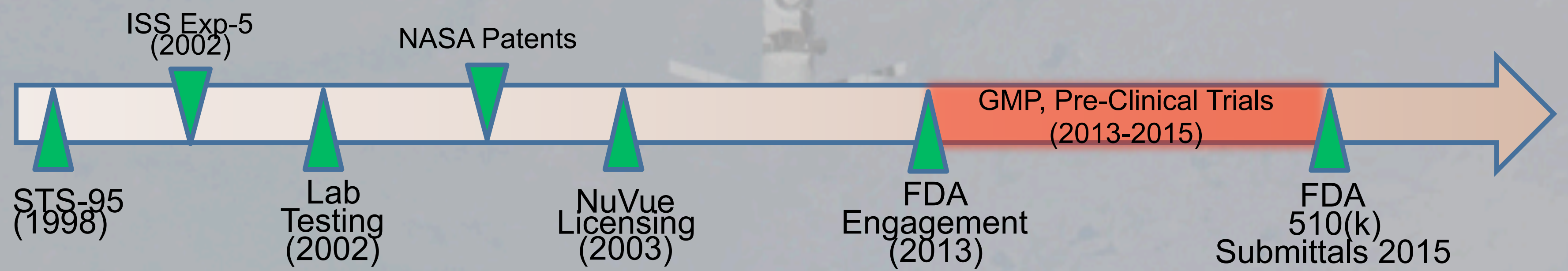
- The NASA Microencapsulation processing system (MEPS) was flown on STS-95 (1998) and ISS Expedition 5 (2002), where the unique behavior of fluids in microgravity led to improvements in microcapsule development.
  - *Microcapsule technology has been tested by many researchers on Earth as a form of cancer treatment by directly injecting microcapsules into tumor sites without the toxic effects of systemic chemotherapy, but several disadvantages have restricted the use of this technology in cancer treatment.*

What spaceflight enabled:

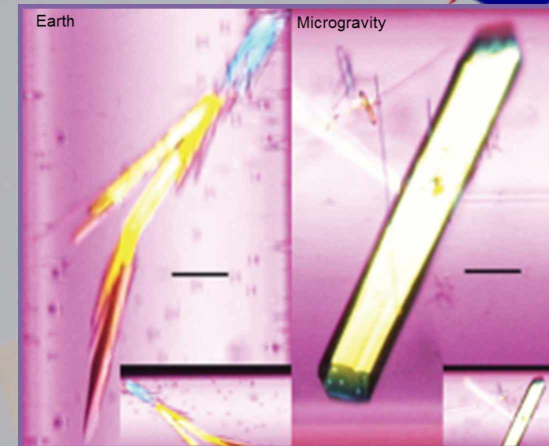
- The space flight results led to the development of a ground-based version of the system (called the Pulse Flow System (PFS)) for Earth-based manufacturing of commercial-scale quantities of the desirable microcapsules that showed significant improvements in treating tumors in laboratory animals.
  - *13 NASA US patents were filed, and are currently licensed to NuVue Therapeutics, Inc.*

What's happening now:

- The MEPS team is currently working closely with the FDA towards three 510(k) applications as visualization markers:
  - Imaging Marker-Microcapsules ("Biopsy Site Marker") for the <u>visualization of tumor tissue sites</u>, (pre and post surgical)
  - Microcapsule Fiducial Imaging Markers for <u>measuring tumor regression</u>
  - Microcapsule Tissue Markers for <u>Magnetic Resonance Imaging compatibility</u> (this was recommended by FDA)
- Results from these studies will also advance development of the chemo markers for future FDA approval



Advancements Enabled by ISS Research



What was done in space:

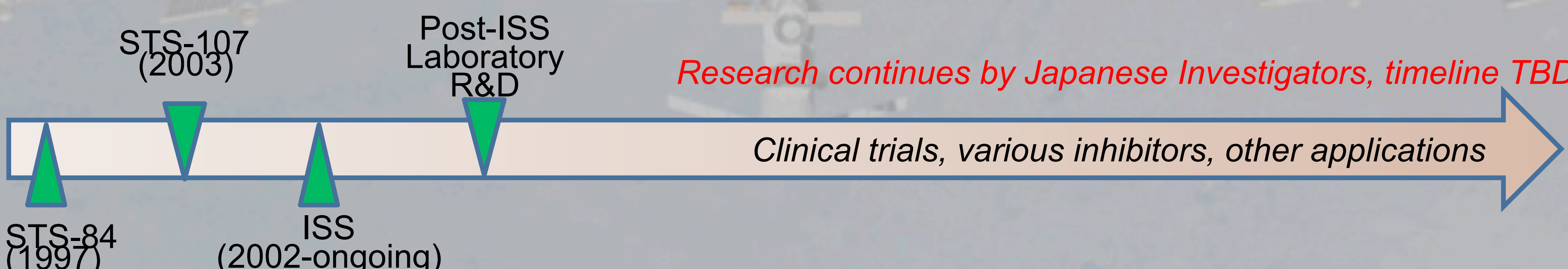
On ISS, Japanese scientists crystallized a protein (H-PGDS) involved in the progression of Duchenne Muscular Dystrophy complexed to its known oral inhibitor (HQL-79) in an effort to grow a 3-dimensional crystal structure that could provide insight on how to improve the inhibitor in Duchenne patients.

What spaceflight enabled:

Lack of sedimentation and convection in microgravity led to the 3-dimensional crystal growth that allowed scientists to identify an improved complex structure and an associated water molecule that was not previously known. Researchers used this discovery to developed an even more potent form of HQL-79 inhibitor for Duchenne in laboratory testing.

What's happening now:

Principal Investigators are studying the effects of the improved inhibitor in pre-clinical studies on animals. Beagle pups treated with the improved inhibitor has shown improvements in slowing the progression of Duchenne.



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